

## CLAIMS

What is Claimed is:

1. A high intensity discharge lamp, comprising:

(a) a lamp bulb envelope composed of single crystal sapphire tubing, the envelope having a tubular burst pressure of at least 4,500 psi at 1,400° C and a maximum tensile strength of 56,000 psi at 1,400° C, the lamp bulb envelope being substantially cylindrical and having an inner diameter of between 1 mm and 25 mm and an outer diameter of at least 2 mm;

(b) a plurality of end plugs composed of one of polycrystalline alumina and single crystal sapphire, the end plugs being situated at opposite ends of the lamp bulb envelope;

(c) first and second electrodes extending through the end plugs so that at least a portion of each of the first and second electrodes is situated within the lamp bulb envelope;

(d) a seal sealing each of the end plugs to an inside wall of the corresponding end of the lamp bulb envelope; and

(e) a fill situated within the lamp bulb envelope,

wherein a voltage is applied to the first and second electrodes to generate an arc plasma therebetween, the voltage being provided by a power supply operating in a continuous non-flash mode, and wherein the arc plasma emits a visible radiation spectrum between 400 nm and 700 nm with a color temperature between 4,000° K and 9,000° K.

2. The lamp according to claim 1, wherein the fill is composed of at least one of mercury and xenon.

3. The lamp according to claim 1, wherein the tubing is without microscopic surface undulations arising from conversion in place from polycrystalline alumina.

4. The lamp according to claim 1, wherein the end plugs are composed of polycrystalline alumina and the seal is composed of glass doped with one of titanium and tungsten.
5. The lamp according to claim 1, wherein the end plugs are composed of single crystal sapphire and wherein a long axis of the end plugs is the C axis which is parallel to C axis of the lamp bulb envelope.
6. The lamp according to claim 1, wherein the end plugs are composed of single crystal sapphire, wherein a clearance distance between the end plugs and the lamp bulb envelope is less than 0.2 mm.
7. The lamp according to claim 1, wherein a surface of the end plugs is coated with a seal material composed of at least one layer of nanostructured alumina-silicate which has between 1% and 5% mixture of titanium dioxide.
8. The lamp according to claim 1, wherein a sealing region is between the lamp bulb envelope and each of the end plugs, the sealing region being sintered between 1,700 and 2,000 °C.
9. The lamp according to claim 1, wherein the end plugs are composed of single crystal sapphire, the end plugs having corresponding integral holes for insertion of the first and second electrodes.
10. The lamp according to claim 9, where the holes are prepared in a stepped manner, each of the holes having a first portion and a second portion, the first portion facing an inside of the lamp bulb envelope, the second portion facing outside of the lamp bulb envelope, the first portion having a smaller diameter than the second portion.

11. The lamp according to claim 9, wherein the holes are generated using a drilling procedure with a laser in the 147 nm or less regime.

12. The lamp according to claim 10, wherein each of the first and second electrodes having an electrode stem and an electrode base, the stem being inserted into the lamp bulb envelope through the first portion of the hole, the electrode base being fitted in the second portion of the hole.

13. The lamp according to claim 1, wherein an operating temperature of the seals is between 600 and 1400 °C.

14. The lamp according to claim 1, wherein an inner diameter of the lamp bulb envelope is between 1 mm and 2 mm and the Grashof number is less than 1400.

15. The lamp according to claim 2, wherein a mercury density of the fill is between 20 and 600 mg/cm<sup>3</sup> and a xenon pressure is between 0.6 atm and 10 atm.

16. The lamp according to claim 1, wherein an operating pressure of the lamp is between 20 atm and 600 atm.

17. The lamp according to claim 1, wherein the correlated color temperature is determined as a function of a type of dopants utilized in the fill, the type of dopants corresponding to a particular application of the lamp, and wherein the correlated color temperature is maintained over a life of the lamp.

18. The lamp according to claim 1, wherein the fill includes a mercury-free fill.

19. The lamp according to claim 18, wherein the fill includes at least one of scandium and rare earth halides.

20. The lamp according to claim 1, wherein an efficacy value of the lamp exceeds 60 lumen per watt.

21. The lamp according to claim 1, wherein the first and second electrodes are separated a predetermined distance, the predetermined distance being less than 2 mm.

22. The lamp according to claim 1, wherein a total radiation flux within the lamp bulb envelope is between 100 and 150 watts/cm<sup>2</sup>.

23. The lamp according to claim 9, wherein each of the end plugs is composed of a single crystal sapphire tube, the tube being generated by an edge grown crystallization process with the integral hole for insertion of the first and second electrodes.

24. The lamp according to claim 1, wherein the power supply operates in a voltage range between 0.1 volt and 600 volts and a current range of between 2 amps and 150 amps

25. The lamp according to claim 1, wherein the power supply is a direct current power supply.

26. The lamp according to claim 1, wherein the power supply is an alternating current power supply.

27. The lamp according to claim 1, wherein the power supply operates with frequency in a range of between 16 cycles per second and over 1,000 cycles per second.

28. A high intensity discharge lamp, comprising:

(a) a lamp bulb envelope composed of single crystal sapphire tubing, the envelope having a tubular burst pressure of at least 4,500 psi at 1,400 °C and a maximum tensile strength of 56,000 psi at 1,400 °C, the lamp bulb envelope being substantially

cylindrical and having an inner diameter of between 1 mm and 25 mm and an outer diameter of at least 2 mm;

(b) a plurality of end plugs composed of one of polycrystalline alumina and single crystal sapphire, the end plugs being situated at opposite ends of the lamp bulb envelope;

(c) first and second electrodes extending through the end plugs so that at least a portion of each of the first and second electrodes is situated within the lamp bulb envelope;

(d) a seal sealing the each of end plugs to an inside wall of the corresponding end of the lamp bulb envelope; and

(e) a fill situated within the lamp bulb envelope,

wherein a voltage is applied to the first and second electrodes to generate an arc plasma therebetween, the voltage being provided by a power supply operating in a continuous non-flash mode, and wherein the lamp is operated in a particular regime so that the arc plasma emitting radiation in a 200 nm to 400 nm ultraviolet region of a radiation spectrum.

29. The lamp according to claim 28, wherein the fill is composed of at least one of mercury and xenon.

30. The lamp according to claim 28, wherein the tubing is without microscopic surface undulations arising from conversion in place from polycrystalline alumina; .

31. The lamp according to claim 28, wherein the fill is composed of xenon and hydrogen.

32. The lamp according to claim 28, wherein the particular regime of the lamp operation is in a temperature range between 9,000 and 15,000 °K.

33. The lamp according to claim 28, wherein the particular regime of the lamp operation is in a pressure range between 0.5 atm and 200 atm.

34. The lamp according to claim 28, wherein the lamp bulb envelope is doped with UV emitting fill materials including at least one of iron chloride, iron bromide, chrome chloride, chrome boride, cadmium and vanadium.

35. The lamp according to claim 34, wherein a temperature of the plasma is in the range of 6000 to 7000 °K and a pressure of the plasma is in the range of 5 atm to 50 atm for maximum emission of line radiation from dopant atoms between 200 and 400 nm.

36. A high intensity discharge lamp, comprising:

(a) a lamp bulb envelope composed of single crystal sapphire tubing, the envelope having a tubular burst pressure of at least 4,500 psi at 1,400 °C and a maximum tensile strength of 56,000 psi at 1,400 °C, the lamp bulb envelope being substantially cylindrical and having an inner diameter of between 1 mm and 25 mm and an outer diameter of at least 2 mm;

(b) a plurality of end plugs composed of one of polycrystalline alumina and single crystal sapphire, the end plugs situated at opposite ends of the lamp bulb envelope;

(c) first and second electrodes extending through the end plugs so that at least a portion of each of the first and second electrodes is situated within the lamp bulb envelope;

(d) a seal sealing each of the end plugs to an inside wall of the corresponding end of the lamp bulb envelope; and

(e) a fill situated within the lamp bulb envelope,

wherein a voltage is applied to the first and second electrodes to generate an arc plasma therebetween, the voltage being provided by a power supply operating in a continuous non-flash mode, and wherein the lamp is operated in a particular regime so that the arc plasma emitting radiation in 700 to 2500 nm infrared region of a radiation spectrum.

37. The lamp according to claim 36, wherein the lamp bulb envelope is doped with infra-red emitting materials including at least one of cesium, potassium and rubidium.

38. The lamp according to claim 36, wherein a temperature of the plasma is in a range of 4000 to 6000 °K and a pressure of the plasma is in the range of 5 atm to 50 atm for maximum emission of line radiation from dopant atoms between 700 and 2500 nm.

39. A method for sealing a plurality of single crystal sapphire end plugs to a single crystal sapphire envelope of a high discharge lamp, comprising the steps of:

(a) polishing the end plugs so that a clearance distance between the end plugs and the envelope is less than 0.2 mm, a long (C) axis of each of the end plugs being parallel to an axis of the envelope;

(b) coating a surface of each of the end plugs with at least one layer of nanostructured alumina-silicate which has between 1% and 5% mixture of titanium dioxide; and

(c) sintering a sealing region by applying heat between 1,700 and 2,000 °C, the sealing region being between the envelope and each of the end plugs.

40. The method according to claim 39, wherein the end plugs have corresponding holes for insertion of first and second electrodes of the lamp.